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ABSTRACT

The selection of elective science courses during high school is believed to act as a filter to future participation in science. This study investigated the research hypothesis that science self-efficacy and gender may be related to ninth grade student intentions to take elective science courses during high school. In this study, the Test of Science Self-Efficacy was developed and administered to ninth grade students in eight Texas high schools. The instrument was designed to assess science self-efficacy for technical skills, tasks, problems and science-related coursework. Students (n=817) were asked to complete this test and a more general academic Student Self-Efficacy Scale. The data were analyzed using correlational procedures. Science self-efficacy was found to be only slightly related to general student self-efficacy, providing support for the proposed domain-specific nature of efficacy beliefs in scientific fields. A small, but statistically significant difference was found between males and females in science self-efficacy, with males scoring higher. Statistically significant gender differences in intentionality were also found, indicating that males intended to take more science classes than females. It is concluded that science self-efficacy may differ from general academic self-efficacy. Males have a slightly higher level of science self-efficacy and intend to take more science classes. (Contains 36 references.) (PR)

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THE RELATIONSHIP OF SCIENCE SELF-EFFICACY AND GENDER TO NINTH GRADE STUDENTS' INTENTIONS TO ENROLL IN ELECTIVE SCIENCE COURSES

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Abstract

The selection of elective science courses during high school is believed to act as a filter to future participation in science. This study investigated the research hypothesis that science self-efficacy and gender may be related to ninth grade students' intentions to take elective science courses during high school. In this study, the Test of Science Self-Efficacy was developed and administered to ninth grade students in eight Texas high schools. The instrument was designed to assess science self-efficacy for technical skills, tasks, problems and science-related coursework. Students were asked to complete this test and a more general academic Student Self-Efficacy Scale. The data were analyzed using correlational procedures. Science self-efficacy was found to be only slightly related to general student self-efficacy, providing support for the proposed domain-specific nature of efficacy beliefs in scientific fields. A small, but statistically significant difference was found between males and females in science self-efficacy, with males scoring higher. In addition, small, but statistically significant, gender differences in intentionality were also found, indicating that males intended to take more science classes than females. The combination of science self-efficacy and gender were able to predict ten percent of the relationship to intentionality. Based on the findings, it was concluded that science self-efficacy may differ considerably from

general academic self-efficacy. Males have a slightly higher level of science self-efficacy and intend to take more science classes. The implications of these findings for the current and future goals of science educators are discussed.

Introduction

The participation of women in scientific and technological fields will increase in importance as America moves in the direction of a high technology society. As increased technology impacts the labor force, society will need to be prepared to meet the demands of high technology jobs requiring specialized skills and talents. Current projections indicate that a long decline in birthrates, in part a consequence of changing lifestyles of women, will result in a decrease in the number of people attending college in the next decade (Finkbeiner, 1987). Colleges are expected to face reduction in enrollment by 1992, and the number of men will not be sufficient to meet the demands for scientists and engineers (McMillen, 1987; Vetter, 1988). Predictions concerning the impact of high technology on the occupational structure indicate that women will be called on to assume an increasingly larger role in the work force.

Over the 1976-1986 decade there has been a 250 percent increase (13 percent annually) in employment of women scientists and engineers, compared with an 84 percent increase (6 percent annually) for men (National Science Foundation, 1988). While the increase in representation of women in science is encouraging, they

still constitute a much smaller ratio of the science and engineering work force. The NSF (1988) reported that women represent 44 percent of all employed persons, 49 percent of those in professional and related occupations and only 15 percent of scientists and engineers. The need for full representation of women in scientific and technological fields continues to be a pressing problem for those involved with science education and research.

Science education researchers are concerned with the need for studies to be undertaken to determine and analyze the factors which relate to female enrollment patterns with regard to science careers and science courses (Kahle, 1983, 1985; Koballa, 1988; Parker, 1986; Matyas, 1984; Jones & Wheatley, 1988; Harding, 1985). It is believed that selection of science courses during high school years may act as a filter for scientific and technological areas (Shemesh & Lazarowitz, 1988). This has led to an exploration of variables that influence or discourage women with regard to enrolling in science courses during high school. Although approximately equal proportions of females and males select academic curricula in high school, females are less likely to take courses in chemistry, physics and advanced mathematics (NSF, 1988). Research has shown that twice as many college bound senior boys as girls have had three years of Physical Science (Skoinick, Langborg & Day, 1982). Through their research, Bowyer, Linn & Stage (1980) have found that females graduate from high school having taken one-half of a

semester less science than males, which may ultimately contribute to the underrepresentation of women in the science and engineering fields.

Self-efficacy theory may be relevant for understanding the high school course selection patterns that eventually contribute to the underrepresentation of women in science. Betz and Hackett (1986) postulate that the concept of self-efficacy expectations may be a useful mechanism for explaining course selection behavior as it relates to understanding the underrepresentation of women in science and engineering fields. In applying self-efficacy theory to the career domain, Betz and Hackett (1981) suggest that differences in gender-role socialization and subsequent experiences associated with sources of self-efficacy information (i.e., past experiences, social persuasion of significant others, vicarious experiences and physiological arousal) may contribute to differences in the development of self-efficacy expectations in men and women.

Theoretical Framework

Self-efficacy theory originates from Bandura's (1986) Social Cognitive Theory, which includes psychological phenomena as important aspects of learning theory. The original theory postulated by Bandura (1977) suggested that a person's behavior and behavior change are mediated by a person's belief concerning his/her ability to perform certain tasks or behaviors. These beliefs are referred to as self-efficacy beliefs, expectations or

judgments. In addition, the self-efficacy construct consists of outcome expectancies--the expectation that specific behaviors will result in desirable outcomes. Self-efficacy expectations were believed to be useful in examining whether behavior would be initiated, the effort expended on the behavior and the duration of the effort (Lent & Hackett, 1987). Thus, self-efficacy can be considered to be a mediating variable in relation to a person's behavioral intentions, and may contribute to our knowledge of behavior such as the intent to enroll in elective science classes.

A factor of considerable importance to the conceptualization of self-efficacy theory is the hypothesized domain-specific nature of self-efficacy beliefs. Self-efficacy theory is believed to correspond to specified domains, which necessitate the construction of task-specific measures of self-efficacy (Hackett & Betz, 1984). This situation-specific construct implies that self-efficacy theory may have utility in explaining behaviors and thought patterns important to science teaching. A review of the literature indicated empirical evidence demonstrating the predictive utility of self-efficacy in various domains such as mathematics and computer science (Schunk, 1987; Miura, 1986). Bandura and Adams (1977) emphasized that self-efficacy measurements must be designed to measure behaviors in the individual domain being studied. These measurements of specific tasks within given domains should include a range of task difficulties. Bandura (1982) suggested that self-efficacy has utility for predicting performance in a variety of

domains, providing the measuring instrument is designed to correspond with specific tasks in a given domain. Gist (1987) suggested that more domain-specific measures of self-efficacy that are associated with clusters of competencies have more predictive powers than general measures of self-efficacy. The domain-specific nature of self-efficacy was taken into account when designing the measurement instrument for this study. Additionally, self-efficacy should be measured in terms of immediately subsequent performance (Gist, 1987). Therefore, confidence ratings on the Test of Science Self-Efficacy developed for this study were based on the perceptions of confidence in regard to performing a task on a given day.

Related Research

Self-efficacy theory has been useful for investigations concerned with behavior and behavior change in all aspects of human development. In an academic context, the concept of self-efficacy has been applied to studies focusing on such diverse areas as school achievement, teacher effectiveness, educational practices, and childrens' acquisition of cognitive skills (Schunk, 1985; Hillman, 1984; Lent & Hackett, 1987). The theory has been applied to career-relevant behaviors to provide an explanation as to why more women than men fail to fully realize their potential in career-related areas (Hackett & Betz, 1981).

Participation of women in mathematics is closely related to their underrepresentation in scientific fields. Mathematics has

been viewed as a persistent barrier to the representation of women in science (Kahle, 1985). Much of the research in relation to career self-efficacy has focused on self-efficacy in the mathematics or computer domains. Fewer studies have examined self-efficacy in terms of science, particularly at the precollege level. Lent, Brown & Larkin (1986) investigated science self-efficacy for technical and scientific fields in a study of 105 undergraduate students considering science and engineering majors. The effectiveness of the self-efficacy variable as a predictor of grades and persistence in these fields was compared with two other variables--interest consequence and consequence thinking. The Self-Efficacy for Technical/Scientific Fields--Educational Requirements and Self-efficacy for Academic Milestones were used to determine self-efficacy strength. Self-efficacy was found to be the most useful of the three variables in predicting grades and persistence in technical/scientific fields. Kerns (1981) developed an instrument to measure chemistry self-efficacy based on Betz and Hackett's Mathematics Self-Efficacy Scale. His measure of chemistry self-efficacy was indicative of gender differences in self-efficacy which was significantly related to gender differences in the selection of a college major

Purpose of the Study

The purpose of the present study was to determine the relationship between science self-efficacy and general academic self-efficacy; to determine if gender differences exist in science

self-efficacy and intentionality; and to determine if science self-efficacy and gender taken together predict ninth grade students' intentions for taking future elective science courses during high school. The domain-specific instrument in this study was designed to obtain efficacy information in relation to science technical skills, tasks, problems and coursework. The study was intended to focus self-efficacy research on the science domain and extend the study of science self-efficacy to diverse high school populations.

A consideration of the role of gender and science self-efficacy in predicting intentions to enroll in elective science courses can contribute to a better understanding of persisting trends concerning the participation of girls in science. The Test of Science Self-Efficacy was developed in response to the need for a self-efficacy measurement instrument relevant to secondary science. The following questions served to guide the study:

(1) Is science self-efficacy different from general academic self-efficacy?

(2) Are there differences between males and females in science self-efficacy?

(3) Are there gender differences with regard to intentionality for taking future elective science courses?

(4) Does science self-efficacy predict the intent to take elective science courses?

(5) How well do science self-efficacy and gender predict the intent to take elective science courses?

Method

Subjects

Eight high schools geographically representing northeast, southeast and east Texas were selected for participation in this study. A major factor in the selection of schools was the availability of science course offerings beyond Physical Science and Biology I. Fourteen Physical Science teachers from these eight high schools voluntarily agreed to participate in the study when contacted by their building principals. The teachers had a range of background experience related to public school science teaching. All had taught more than one science subject in public schools. The study was conducted with 44 intact sections of regular, honors or gifted and talented ninth grade Physical Science classes. Introductory Physical Science classes were not included in the study as future science course enrollment for students having taken introductory Physical Science is severely limited.

Eight hundred ninety-one students completed the initial demographic questionnaire, Test of Science Self-Efficacy and Student Self-Efficacy Scale. Eight hundred seventeen ninth grade Physical Science students ultimately comprised the study sample, after the elimination from the study of 74 tenth, eleventh and twelfth graders enrolled in Physical Science. The students ranged in age from 14 to 17. These students' scholastic abilities, as reported by their perceived grade point average, ranged from items labelled mostly below D to items labelled mostly A. The study

sample was comprised of 430 females and 387 male students representing a diversity of ethnic groups and socioeconomic status, with caucasians, blacks and hispanics each constituting a majority at different schools. The participating students seemed to reflect a variety of socio-economic levels, as represented by information related to state funded free lunch programs. Each school participating in the study provided an ethnic and socio-economic breakdown of the students served by the school.

Procedures

A domain-specific test instrument was needed to investigate the research questions of interest in relation to science self-efficacy. While no such test was available, the Mathematics Self-Efficacy Scale, developed by Betz and Hackett (1983), served as a model for the construction of a science self-efficacy instrument. The completion of the following prerequisite tasks was necessary before the instrument could be used with the study population: (1) specification of the domain of science-related behaviors, (2) selection of representative science-related behaviors, (3) construction of a science self-efficacy instrument, (4) determination of test readability, (5) administration of the pilot study, and (6) determination of the validity and reliability of the test.

Data collection was initiated in February of 1989. The researcher provided a brief testing orientation at each high school for participating teachers. At this time, each teacher was given

a test packet containing both test instruments, an answer sheet, a demographic information sheet, test directions and guidelines for administering the tests. The test administrators were given a set of statements to use to ensure uniformity in the communication of test directions to students.

Students were provided with information concerning the sequence of courses which were available to them, the types of content studied and the potential prerequisite skills which they may need to successfully complete courses. The Test of Science Self-Efficacy, the Student Self-Efficacy Scale and a demographic questionnaire were completed by each student.

Measures

The rationale for the development of the Test of Science Self-Efficacy included the need for self-efficacy beliefs to be measured along a continuum of response, as represented by a Likert scale. The domain-specific nature of self-efficacy beliefs was important in constructing an instrument relevant to secondary science. Students were asked to rate, on a five-point Likert scale, their confidence with regard to science technical skills, science tasks, science problems and science-related coursework. The Fry Readability Scale (Fry, 1968) and the Harris-Jacobson reading formula (1980) were used to determine the readability of the test, in order to assure that reading difficulty was not a variable influencing the results. The test material corresponded to a seventh grade reading level. In retrospec, a seventh grade

readability may be too high for those ninth grade students who have reading difficulties.

Cronbach's alpha reliability for the 76-item Test of Science Self-Efficacy was determined to be 0.96
using the TESTAT routine. Four science educators, four scientists in different fields of study and one science supervisor established the content validity of the instrument on the basis of the extent to which it represented secondary science content. Ary, Jacobs, and Razavich (1985) suggested that content experts can effectively judge the adequacy and representativeness of the measuring instrument for the purpose of establishing content validity. The criterion-related validity was established, in part, by the relationship observed between science self-efficacy and the dependent variable of intentionality. However, a true measure of criterion validity would necessitate correlating the relationship between science self-efficacy and intention to take science courses with students' actual behaviors. This was not done due to limitations in relation to future access to the study population. Since science self-efficacy was the construct under consideration, it was correlated to measures of general self-efficacy to determine the degree of dependence or independence associated with the construct.

Additional assessment instruments included the Student Self-Efficacy Scale (Hillman, 1986), which served as a general academic self-efficacy scale, and a demographic questionnaire. A general

academic measure of self-efficacy was needed as a comparative gauge in order to establish a basis for measuring domain-specific self-efficacy in science. The Student Self-Efficacy Scale was written for grades three through twelve and focuses on questions related to an academic context. A questionnaire was developed to collect demographic information of importance to the study. The questionnaire was designed to obtain information pertaining to gender, age, current grade level and perceived grade point average. Students were also asked to indicate all science courses they intended to take during high school, as well as any science classes outside of the high school curriculum they intended to take.

Analysis of Data

Information obtained from the demographic questionnaire was coded by the researcher and entered into two data files. The semester unit was used as the unit of analysis for behavioral intentions, and was coded according to the number of semester hours of science students intended to take. Data analyses were accomplished using the TESTAT and REGRAN routines of the Veldman Statistical Package (1967). Using these routines, total test scores were obtained and a Pearson-Product Moment correlation was calculated to determine the direction and strength of the relationship between general self-efficacy and science self-efficacy. Pearson-Product Moment correlation was also used to determine the relationship of the independent variables of science self-efficacy and gender to the dependent variable of

intentionality. Multiple correlation was performed to determine how gender and science self-efficacy taken together are related to intentionality.

Results

Science Self-Efficacy and Student Academic Self-Efficacy

The relationship between science self-efficacy and student academic self-efficacy was significant at the .01 level of significance. The shared variance explains approximately one percent of the relationship between science self-efficacy and student academic self-efficacy. These results appear to be consistent with studies which suggest the domain-specific nature of self-efficacy (Hackett & Betz, 1984; Bandura, 1982; Miura, 1986).

Gender and Science Self-Efficacy

There were statistically significant differences in science self-efficacy between males and females at the .05 level of significance. The direction of the relationship indicates that boys tend to have a slightly higher degree of science self-efficacy than do girls.

Science Self-Efficacy as a Predictor of Intentionality

The statistically significant relationship between science self-efficacy and intentionality was at the .01 level of significance. Science self-efficacy appears to contribute approximately nine percent of the variance in the prediction of intentionality. The direction of the relationship indicates that science self-efficacy and intentionality are inversely related.

Science Self-Efficacy and Gender as a Predicator of Intentionality

The statistically significant relationship between science self-efficacy and gender taken together and intentionality is at the .01 level of significance. The combination of science self-efficacy and gender appear to predict approximately ten percent of the variance with regard to intentions for taking elective science courses.

Discussion

The question of difference between science self-efficacy and a more global measure of self-efficacy was originally posed to see if there was evidence to support the hypothesized domain-specific nature of self-efficacy, particularly in relation to the domain of science. The results are consistent with the belief that self-efficacy corresponds to specified domains (Hackett & Betz, 1984; Bandura & Adams, 1977). Although a significant positive relationship was found between the two, since only one percent of the relationship could be explained by the results, this indicated that the two self-efficacy measures were intercorrelated at a low level. The findings suggested that the two measures reflect slightly related, but quite different aspects of efficacy expectations. It would be reasonable to expect some relationship between science self-efficacy and student academic self-efficacy, but that this relationship is not large, is supported by the

results, thus lending support to the hypothesized domain-specificity of efficacy beliefs.

Previous studies investigating gender differences in self-efficacy have provided conflicting results. Betz and Hackett (1981, 1983) for example, found evidence in support of differences in self-efficacy favoring males, while Lent, Brown and Larkin (1986) failed to find gender differences in self-efficacy judgments related to technical-scientific fields. The findings which emerged from this study illustrate a negative correlation in which females scored lower on science self-efficacy than did males, as suggested by the difference in means. Since less than one percent of the relationship between gender and self-efficacy can be predicted, the practical significance of the findings may be somewhat limited. The results, however, are consistent with Lent, Brown and Larkin's (1986) conclusion that the practical contribution of small amounts of self-efficacy variance could be challenged, but are nevertheless consistent with the self-efficacy model which posits "that efficacy beliefs provide valuable, but often not sufficient information for predicting behavior."

While behavioral intentions do not always correspond to actually performing the behavior, it has been suggested that the more general the behavioral intention, the weaker the relation between behavioral intention and actual behavior will be (Koballa, 1988). The intent to take science classes during high school

appears to be a fairly specific behavior. Therefore, if behavioral intentions accurately reflected the behavior, then these findings which indicated that females have lower intentionality scores may reflect science course-enrollment patterns, as found in the literature. Studies have shown that girls graduate from high school having taken fewer measurable semester units of science than males (Bowyer, Linn & Stage, 1980; Pallas & Alexander, 1983). In this study, where gender accounts for only one percent of the variance in the relationship between gender and intentionality, the weakness inherent in the nature of self-report instruments is a factor that should be given consideration. Although the findings of this study indicate that females have a lower self-efficacy and intend to take fewer elective science courses, these findings may not be problematic for women. They may indicate that women have a more realistic awareness of their limitations, whereas men may tend to overestimate their capabilities in regard to science.

Previous studies gave the researcher a basis for expecting an observable correlation between science self-efficacy and intentionality. For example, studies of self-efficacy in relation to intent to take computer courses and math courses (Miura, 1986; Lent & Hackett, 1987) have provided evidence of a significant relationship between domain-specific self-efficacy and intentionality. Science Self-efficacy appeared to contribute approximately nine percent of the variance in the observed

relationship with the variable of intent to take elective science courses. The negative correlation that was found suggested that a high level of science self-efficacy corresponds to a lower level of intentionality. This contradicted the expected findings of the researcher and was inconsistent with the findings of the previous questions. Based on the relationship observed in this correlation it would be expected that the lower intentionality scores observed for females would correspond to a high level of science self-efficacy. However, this was not the case, as females appeared to have both a lower degree of intentionality and lower science self-efficacy. Since this question was analyzed with males and females combined, the inverse relationship is probably a result of the lower self-efficacy and intentionality scores of females noted earlier. Gender and science self-efficacy, together, appeared to account for approximately ten percent of the observed relationship with intent to take elective science courses. These two variables, when taken together, predict a greater portion of the relationship than either variable considered separately.

Implications

This study suggests implications for identifying appropriate levels of specificity for measuring self-efficacy. The following practical implications derived from this study include: (1) implications for career guidance in which students can consider their own abilities in relation to science, and (2) implications

for theory-based classroom and counseling interventions in relation to career choice and development. Specifically, the results suggest that counselors should take care not to over-emphasize the importance of self-efficacy in course selection, but at the same time, should not ignore the potential influence of efficacy beliefs on future course selection behavior.

Theoretical implications derived from this study imply that males and females do not differ greatly in their efficacy beliefs or have not yet formulated accurate self-efficacy judgments. The pattern of behavioral intentions found in this study do not provide an accurate indication of actual science course enrollment patterns previously reported, or it may be that science course enrollment patterns are becoming more equitable for women.

More work is needed to increase the theoretical and professional confidence in the ability of the self-efficacy model to explain the links between self-efficacy and behavior. Therefore, studies that investigate causal connections between self-efficacy and science-related behaviors are needed.

The self-efficacy model should be extended to diverse settings, special populations and developmental tasks. Since differences that may ultimately lead to differential science course enrollments may form during the elementary years or earlier, self-efficacy theory should address these early differences. It should address different levels of cognitive tasks, as well.

Finally, it is suggested that self-efficacy and gender are not the only factors contributing to course selection patterns in science. Research should focus on other variables that may interact with self-efficacy and gender, or contribute to understanding behavioral intentions in relation to course enrollment in science.

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